THE WORK OF THE INTERNATIONAL X-RAY UNIT COMMITTEE AND THE INTERNATIONAL X-RAY AND RADIUM PROTECTION COMMISSION DURING THE III INTERNATIONAL CONGRESS OF RADIOLOGY IN PARIS 1931

During the III International Congress of Radiology in Paris, July 1931, meetings were held by the »International X-Ray Unit Committee» and the »International X-Ray and Radium Protection Commission» which had been formed earlier on the initiative of British radiologists and physicists. The work of both these committees was marked by great interest on the part of all the members, and the recommendations adopted at the II International Congress of Radiology in Stockholm in 1928 were revised, which involved improvements as well as additions.

International X-Ray Unit Committee

After a revision of the earlier Recommendations of the Committee, the following proposal, in which alterations and additions to the Recommendations adopted by the Stockholm Congress are italicized, was submitted to the Executive Committee of the III International Congress. In some cases commentaries have been added in notes, containing the opinion of one of the Swedish members of the Committee on the various questions.

RECOMMENDATIONS OF THE INTERNATIONAL X-RAY UNIT COMMITTEE

The following recommendations are put forward by the undersigned members of the International X-ray Unit Committee for approval by the Executive Committee of the Third International Congress of Radiology:

1) The International Unit of X-radiation shall be the quantity which, when the secondary electrons are fully utilized and the wall effect of the chamber is avoided, produces in one cubic centimetre of atmospheric air at 0° C and 76 cm.

mercury pressure, such a degree of conductivity that one electrostatic unit of charge is measured at saturation current.

2) The International Unit of X-radiation shall be called the »Röntgen» and shall be designated by the letter 'r'.

3) *The »intensity» of the radiation shall be expressed in 'r' per minute or 'r' per second.*

4) Various standard methods shall be employed to establish the unit.

5) *All data given in Röntgen (r-units) shall be supplied with an index to distinguish between the incident dose which does not include the scattered radiation, and the effective dose which includes the scattered radiation.*

6) For all comparative purposes it is advisable to employ ionization chambers which have been calibrated in terms of a standard chamber for X-radiation of the various qualities employed. It is also advisable to make the wall effects of these chambers as small as possible.

7) The practical instrument used to measure X-ray output shall be called a dosage-meter (Dosismesser, dosimètre).

8) The constancy of the indications of the dosage meter shall be tested by means of gamma radiation emitted from a definite quantity of radium element, the measurement being carried out always under the same conditions.

9) Any specification of dosage is incomplete without specifying the quality as well as the quantity of the radiation. *For practical purposes it suffices to specify the quality of the X-radiation in terms of the half-value layer in copper when this value exceeds 0.1 m/m of copper, or in terms of the half value layer in aluminium for*

Ad. 3. This addition was made on the proposal of several members of the Committee[1]. The necessity of adopting a measure for the roentgen ray intensity is obvious. A statement of the »dosis» alone means that differences in radiation results caused by a possible time factor might easily be overlooked. It would have been better if from the first a u n i t o f i n t e n s i t y had been selected instead of the dose-unite »r», called for instance Ir, when the dose would be expressed in Ir-minutes. The primary information — intensity and time — would then have been given a more logical and prominent place among the data determining a radiation treatment.

Ad. 5. By introducing this point, the Committee has attempted to remedy the former uncertainty and confusion in statements of doses given. The comparison between various methods of treatment described in the literature has been rendered difficult by certain authors not stating whether the effect of the scattered radiation from the body is included or not, and mistakes were therefore apt to be made. In dosing, the r-unit is in Sweden used practically exclusively in the sense »the incident dose». The committee might appropriately have proposed a definite index also, so that, for instance, r_i would mean »the incident dose» and r_e »the effective dose». The unit used in Sweden would thus be designated r_i.

Ad. 9. In the earlier Recommendations this point had only been worked in a general sense, and did not include any definite proposal as to how the quality of the radiation should be stated. For medical purposes it is now considered sufficient if the half-value layer and the maximum voltage are given. In Sweden, X-ray machines with kenotrons and condensers are now almost exclusively used, in which the quality of radiation is unambi-

[1] cf. inter alia SIEVERT, Acta Radiol. 122, p. 300, 1931.

radiation of less penetration. In all cases the value of the maximum voltage applied to the terminals of the tube shall be stated.

The specification of the dosage shall also include, in addition to intensity and quality, such factors as the intervals between the times of irradiation, size of field, etc.

The International X-Ray Unit Committee further recommends that:

1) The experimental method of establishing a standard for the determination of the International X-ray Unit shall be entrusted to a sub-committee consisting of the following members of the Unit Committee: M. de BROGLIE (France) W. FRIEDRICH (Germany), E. A. OWEN (Gt. Britain), R. SIEVERT (Sweden), I. SOLOMON (France), E. PUGNO-VANONI (Italy), L. S. TAYLOR (U.S.A.) (Honorary Secretary of the Committee, E. A. OWEN). This committee shall invite the collaboration of the various existing national bureaus for standard measurements and also those about to be instituted.

2) This committee shall consider (a) methods of controlling the constancy of dosage meters, (b) the correlation of X-ray and gamma-ray dosage, (c) the establishment of a gamma-ray unit of intensity.

3) The progress of the work done by the sub-committee shall be reported once a year to the members of the International X-ray Unit Committee.

4) Each country shall be requested immediately to elect their two representatives on the International X-ray Unit Committee; until new representatives are elected, the present members shall serve.

5) The international Committee shall henceforth be called »The International Committee for Radiological Units».

International X-Ray and Radium Protection Commission

After revision of the Recommendations adopted in Stockholm in 1928, these have been given the following wording, in which alterations and additions have been italicized here also and the comments of the Swedish member of the Committee have been added.

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guously determined, even if the maximum voltage and the filter alone are stated. This is probably one of the greatest advantages of this type of X-ray machine.

The last sentence of the paragraph is a request to the doctor to add to his statement of the dose as detailed information as possible regarding all data of importance to the treatment. The information given on this point, at least in the literature, is remarkably scanty. This may possibly be the main reason for the fact that different doctors, using »the same method of radiation», frequently obtain very divergent results of the treatment.

Ad. 1—5. The Committee does not consider its work concluded, but suggests a program for continued activity under a changed name, »The International Committee for Radiological Units». As appears from the proposed program of work for the next three years, the questions to be dealt with are chiefly those connected with the introduction of uniform dosage in radium therapeutics also. As regards the attitude of the Swedish members of the committee to these questions, we refer to an earlier article in this journal[1].

[1] SIEVERT loc. cit.

INTERNATIONAL RECOMMENDATIONS FOR X-RAY AND RADIUM PROTECTION

Revised by the International X-ray and Radium Protection Commission at the Third International Congress of Radiology, Paris, July 1931.

Members:

Dr. G. GROSSMANN, Germany.
Dr. R. LEDOUX-LEBARD, France.
Dr. R. SIEVERT, Sweden.
Dr. I. SOLOMON, France.
Dr. L. S. TAYLOR, United States.
Dr. E. PUGNO-VANONI, Italy.
Dr. G. W. C. KAYE, Great Britain } Hon.
Dr. S. MELVILLE, Great Britain } Secs.

International Recommendations

1. The dangers of over exposure to X-rays and radium can be avoided by the provision of adequate protection and suitable working conditions. It is the duty of those in charge of X-ray and radium departments to ensure such conditions for their personnel. The known effects to be guarded against are:

(a) Injuries to the superficial tissues;
(b) Derangements of internal organs and changes in the blood.

I. Working Hours etc.

2. The following working hours etc. are recommended for whole-time X-ray and radium workers.

(a) Not more than seven working hours a day.
(b) Not more than five working days a week. The off-days to be spent as much as possible out of doors.
(c) Not less than 4 weeks holiday a year, *preferably consecutively.*
(d) Whole-time workers in hospital X-ray and radium departments should not be called upon for other hospital service.
(e) *X-ray and particularly radium workers should be systematically submitted, both on entry and subsequently at least twice a year, to expert medical, general and blood examinations. These examinations will determine the acceptance, refusal, limitation or termination of such occupation.*

II. General X-Ray Recommendations

3. X-ray departments should not be situated below ground floor level.

4. All rooms, including dark rooms, should be provided with windows affording good natural lighting and ready facilities for admitting sunshine and fresh air whenever possible.

5. All rooms should be provided with adequate exhaust ventilation capable of renewing the air of the room not less than 10 times an hour. Air inlets and outlets should be arranged to afford cross-wise ventilation of the room.

Ad. 2 (e). One inevitably wonders in how many radiological clinics such continuous control of the state of health has really been accomplished! The systematic introduction of such a safeguard in all hospitals where radiological work is done would be highly desirable.

6. All rooms should preferably be decorated in light colours.

7. A working temperature of about 18° C. (65° F.) is desirable in X-ray rooms.

8. X-ray rooms should be large enough to permit a convenient lay-out of the equipment. A minimum floor area of 250 sq. ft. (25 sq. metres) is recommended for X-ray rooms and 100 sq. ft. (10 sq. metres) for dark rooms. Ceilings should be not less than 11 ft. (3.5 metres) high.

9. Wherever practicable the X-ray generating apparatus should be placed in a separate room from the X-ray tube.

III. X-Ray Protective Recommendations

10. An X-ray operator should on no account expose himself unnecessarily to a direct beam of X-rays.

11. An operator should place himself as remote as practicable from the X-ray tube.

12. The X-ray tube should be surrounded as completely as possible with protective material of adequate lead equivalent.

13. The following lead equivalents are recommended *under average conditions:*

X-rays generated by peak voltages	Minimum equivalent thickness of lead
Not exceeding . . . . . 75 k.V.	1 mm.
» » . . . . . 100 »	1.5 »
» » . . . . . 125 »	2 »
» » . . . . . 150 »	2.5 »
» » . . . . . 175 »	3 »
» » . . . . . 200 »	3 »
» » . . . . . *250* »	*6* »
» » . . . . . *300* »	*9* »
» » . . . . . *350* »	*12* »
» » . . . . . *400* »	*15* »

14. In the case of diagnostic work, the operator should be afforded protection from scattered rays by a screen of a minimum lead equivalent of 1 mm.

Ad. 11. The following sentence has been excluded from this point: »It should not be possible for a well rested eye of normal acuity to detect in the dark appreciable fluorescence of a screen placed in the permanent position of the operator.» This is because experience has proved that under certain conditions and with certain fluoroscopic screens a noticeable fluorescence does not necessarily mean that the radiation intensity is too large. Neither is it suitable that so subjective a method of examining the protection should in any way be recommended.

Ad. 13. For the previous »as adequate» has been substituted »under average conditions». Circumstances are quite conceivable where the recommended minimum protection is not enough or else unnecessarily large. In any case it will be the local conditions, and not least the thickness of the protective walls (see para. 15), that must decide whether deviations from the table of para. 13 can be justified or not.

15. In the case of X-ray treatment the operator is best stationed completely outside the X-ray room behind a protective wall of a minimum lead equivalent of 2 mm. This figure should be correspondingly increased if the protective value of the X-ray tube enclosure falls short of the values given in paragraph 13. In such event the remaining walls, floor and ceiling may also be required to provide supplementary protection for adjacent occupants to an extent depending on the circumstances.

16. Screening examinations should be conducted as rapidly as possible with minimum intensities and apertures. *Palpation with the hand should be reduced to the minimum.*

17. The lead glass of fluorescent screens should have the protective values recommended in paragraph 13.

18. In the case of screening stands the fluorescent screen should, if necessary, be provided with a protective »surround» so that adequate protection against direct radiation is afforded for all positions of the screen and diaphragm.

19. Screening stands and couches should provide adequate arrangements for protecting the operator against scattered radiation from the patient.

20. Inspection windows in screens and walls should have protective lead values equivalent to that of the surrounding screen or wall.

21. Efficient safeguards should be adopted to avoid the omission of a metal filter in X-ray treatment.

22. Protective gloves, which should be suitably lined with fabric or other material, should have a protective value not less than $^1/_3$ mm lead throughout both back and front (including fingers and wrist). Protective aprons should have a minimum lead value of $^1/_2$ mm.

IV. Electrical Precautions in X-Ray Rooms

23. The floor-covering of the X-ray room should be of insulating material such as wood, rubber or linoleum.

24. Overhead conductors should be not less than 9 ft. (3 metres) from the floor. They should consist of stout metal tubing or other coronaless type of conductor. The associated connecting leads should be of coronaless wire kept taut by suitable rheophores.

25. Wherever possible earthed guards *or earthed sheaths* should be provided to shield the more adjacent parts of the high tension system. *The use of X-ray*

Ad. 16. The addition in this paragraph will be considered an obvious one by all radiologists. With the generally well developed protection of today, palpation will be one of the few occasions, not to say the only one, where the radiologist is exposed to direct X-ray radiation.

Ad. 22. The earlier figure, $^1/_2$ mm of lead, has been changed to $^1/_3$ mm., as there seem to be no suitable gloves in the market giving better protection.

Ad. 25. As regards the recommendations of the use of X-ray equipments having the high tension circuits completely enclosed in earthed sheaths it may be pointed out that, apart from reducing the danger of touching the high voltage lines, another advantage is also gained by these arrangements. The poisonous gases arising chiefly from corona effects and sparking are not given an opportunity to foul the air in the treatment room.

equipment having the high tension circuit completely enclosed in earthed conductors is specially recommended. Unless there are reasons to the contrary, metal parts of the apparatus and room should be efficiently earthed.

26. The use of quick acting double-pole circuit breakers is recommended. Over-powered fuses should not be used. If more than one apparatus is operated from a common generator, suitable overhead multi-way switches should be provided.

27. Some suitable form of kilovoltmeter should be provided to afford a measure of the voltage operating the X-ray tube.

28. *Special electrical precautions should be taken in rooms where anaesthetics are used in conjunction with X-rays.*

V. Film Storage Precautions

29. *The use of non-inflammable X-ray films should be encouraged. In the case of inflammable films, suitable precautions should be taken as regards their use and storage. Large stocks should be kept in isolated stores, preferably in a separate building or on the roof.*

VI. Radium Protective Recommendations

A) Radium Salts

30. Protection for radium workers is required from the effects of:

(a) Beta rays upon the hands;

(b) Gamma rays upon the internal organs, vascular and reproductive systems.

31. In order to protect the hands from beta rays, reliance should be placed, in the first place, on distance. The radium should be manipulated with long-handled forceps, and should be carried from place to place in long-handled boxes, lined on all sides with at least 1 cm. of lead. All manipulations should be carried out as rapidly as possible.

32. Radium, when not in use, should be stored in a safe as distant as possible from the personnel. It is recommended that radium tubes or applicators be inserted

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Ad. 28 and 29. These paragraphs did not exist in the earlier Recommendations, but will need no justification.

Ad. 31. In the corresponding previous paragraph it was pointed out that the forceps should be »preferably made of wood». As the secondary beta-radiation is largest in materils of low and high atomic weight, but reaches a minimum for the materials Ni, Fe, Cu, and Zn, there is no reason why wood should be used.

Ad. 32. The rules regarding lead protection when storing radium have been changed so that if the stipulations of the table are followed, the radiation penetrating will be of the same magnitude, irrespective of the radium quantity. The protection given by the lead thicknesses recommended is more than ample as regards risks to the staff. It is, however, generally of great importance that attention be given also to such radiation measurements as may conceivably be made in connection with radiological treatment, and the gamma rays should therefore be effectively screened off.

into separate lead blocks in the safe, giving a thickness of protective wall amounting to *the values given in the following table:*

Maximum quantity of radium element	*Thickness of lead*
0.2 gm.	*8.5 cm.*
0.5 »	*10* »
1.0 »	*11.5* »
2.0 »	*13* »
5.0 »	*15* »
10.0 »	*17* »

33. A separate room should be provided for the »make-up» of screened tubes and applicators, and this room should only be occupied during such work.

34. In order to protect the body from the penetrating gamma rays during handling of the radium, a screen of not less than 2.5 cm of lead should be used, and proximity to the radium should only occur during actual work and for as short a time as possible.

35. The measurement room should be a separate room and it should *preferably* contain the radium only during its actual measurement.

36. Nurses and attendants should not remain in the same room as patients undergoing radium treatment *with quantities exceeding* $^1/_2$ *gm.*

37. All unskilled work or work which can be learnt in a short period of time should preferably be carried out by temporary workers, who should be engaged on such work for periods not exceeding 6 months. This applies especially to nurses and those engaged in »making-up» applicators.

38. Discretion should be exercised in transmitting radium salts by post. In the case of small quantities it is recommended that the container should be lined throughout with lead not less than 5 cm thick. It is more satisfactory to transport large quantities by hand in a suitably designed carrying case.

B) Emanation

39. In the manipulation of emanation, protection against the beta and gamma rays has likewise to be provided.

40. The handling of emanation should be carried out, as far as possible, during its relatively inactive state.

41. The escape of emanation should be very carefully guarded against, and the room in which it is prepared should be provided with an exhaust fan.

Ad. 36. The italicized addition has been introduced for the reason that the rule should be applicable principally in treatments with large radium quantities, e. g. in distance treatments.

Possibly an addition ought to have been made to this, for instance »or remain at a distance less than 2 metres from patients undergoing treatment with quantities of radium smaller than $^1/_2$ gr.» Perhaps a rider should also be added referring to the fact that distance is the best protection against radium.

42. Where emanation is likely to come in direct contact with the fingers, thin rubber gloves should be worn to avoid contamination of the hands with active deposit. Otherwise, the protective measure recommended for radium salts should be carried out.

43. *The pumping room should preferably be contained in a separate building.* The room should be provided with a connecting tube from the special room in which the radium is stored in solution. The radium in solution should be heavily screened to protect people working in adjacent rooms. This is preferably done by placing the radium in solution in a lead lined box; the thickness of lead recommended being according to the table in paragraph 32.

Beside revising the Recommendations of the X-ray and Radium Protection Commission, the Committee resolved to collect information, before the next congress, from those radiologists who work with teleradium treatment with radium regarding their experiences of the risks and the need of protection in this method of treatment.

The present rapid development of X-ray Curie therapeutics is reflected in the alterations and additions indicated in the above report on the work of the two Committees. The Recommendations of the two Committees will in all probability require to be revised or supplemented again, even at the next International Congress of Radiology.

These International Recommendations obviously cannot in every respect be the rule and guide of radiological work in the several countries. Nevertheless they provide a firm foundation to build on, which is of importance not least when proposals have to be made for legislation to regulate work with X-rays and radium rays. In any case, they lead to cooperation and a valuable exchange of ideas among some of the radiologists of the various countries, and so contribute, not inconsiderably, to increased interest in the International Congresses of Radiology.

Ad. 43. In earlier Recommendations the necessity was pointed out that a separate room for pumping emanation should be used. In view of the risks arising from diffusion of emanation to adjacent premises, it has been recommended that the pumping plant should if possible be placed in a separate building. This is also suitable in view of the difficulty of making radiation measurements in a building where even very small quantities of emanation are present in the air.